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A theory has been developed for reasoning about what is logically possible. The immediate motivation for this research is that advanced logic programming languages involved a non-deducibility primitive(THNOT in PLANNER, one use of CUT in PROLOG) which says to infer something if its negation is not deducible.

The immediate significance of these results is that we now have effective axiomatizations for proving the correctness of logic programs involving non-deducibility primitives, and of various kinds of truth maintenance systems. However, the overall significance of this result transends this particular application to program verification, because it provides the correct axiomatization of this concept, and much of the research on the logical representation of knowledge in AI presupposes a solution to this very problem. (KR)4

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FINAL REPORT
AUTOMATIC INFERENCE IN QUANTIFIED COMPUTATIONAL LOGIC
DAAG29-85-C-0022

Artificial Intelligence Research Institute of Texas, Inc.
Dr. Frank M. Brown

Brief Outline of Research Findings

During this grant we have developed a theory for reasoning about what is logically possible. The immediate motivation for this research is that advanced logic programming languages involve a non-deducibility primitive(THNOT in PLANNER, one use of CUT in PROLOG) which says to infer something if its negation is not deducible:

$$((\neg(\text{DEDUCIBLE}(\neg\ P))) \rightarrow P)$$

The problem of effectively axiomatizing this notion of non-deducibility has been an open problem in the AI literature for at least a decade and numerous attempts to solve this problem have been made under the labels of "Nonmonotonic reasoning", "default logic", "autoepistemic logic", but none of these attempts have resulted in a theory which can explain the reasoning involved with systems of axioms containing arbitrary occurences of:

$$(\neg(\text{DEDUCIBLE}(\neg\ ...)))$$

embedded within sentences of the first order logic.

This year we have produced a theory which effectively axiomatizes this concept and which can explain the reasoning involved in such systems. Our solution is based on modeling:

$$(\neg(\text{DEDUCIBLE}(\neg\ ...)))$$

as:

$$(<>(K\wedge\ ...P))$$

where POS is the possibility symbol of a very strong modal logic called Z which essentially captures a modal notion of logical consistency, and where K is synonomous to the conjunction of all the non-logical axioms.

The immediate significance of these results is that we now have effective axiomatizations for proving the correctness of logic programs involving non-deducibility primitives, and of various kinds of truth maintenance systems. However, the overall significance of this result transends this particular application to program verification, because it provides the correct axiomatization of this concept, and much of the research on the logical representation of knowledge in AI presupposes a solution to this very problem. In particular, progress on default reasoning with conflicting defaults, truth maintenance systems, the frame problem in robot plan formation, and various epistomological problems all seem to presuppose such

a solution. Various aspects of these results were reported in almost all the major AI conferences held in the summer of 1986.

Just as example of the significance of this work for knowledge representation we point out that we have requesed and have been awarded funds by the American Association for Artificial Intelligence and the U.S. Army Research Office to hold a workshop on the Frame problem in robot plan formation this spring.

Previous years work on our automatic deduction system SYMEVAL, along with additional revisions carried this last year, has finally been published in ARTIFICIAL INTELLIGENCE. This paper is 146 pages long and describes a new more natural approach to automatic deduction which is not based on the unification algorithm.

List of Manuscripts Published under ARO Sponsorship

1985

85-1 Brown F.M.,Liu P., "A Logic Programming and Verification System for Recursive Quantificational Logic" (AIRIT TR 85-1) INTERNATIONAL JOINT CONFERENCE ON ARTIFICIAL INTELLIGENCE 85. August 1985.

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1986

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86-2 Brown,F.M., "Reasoning in a Hierarchy of Deontic Defaults", (AIRIT TR-86-2) PROCEEDINGS SIXTH CANADIAN CONFERENCE ON ARTIFICIAL INTELLIGENCE CONFERENCE, AI86, Montreal, CANADA, May 1986.

86-3 BROWN,F.M., "A Commonsense Theory of NonMonotonic Reasoning" (AIRIT TR-86-3 old title: "Toward a Commonsence Theory of Nonmonotonicity") PROCEEDINGS OF THE 8TH INTERNATIONAL CONFERENCE ON AUTOMATED DEDUCTION, Oxford, England, July 1986.

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88-2 Brown,F.M.,S.Park,J.Phelps, "ZPLAN", 9th International Conference on Automated Deduction, Springer Verlag, 1988.

88-3 Park,S. and Brown,F.M. "Reflective Reasoning: A Deductional Calculas of Common Sense Reasoning" THE THIRD ANNUAL ROCKY MOUNTAIN CONFERENCE ON ARTIFICIAL INTELLIGENCE June 13-15, 1988.

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